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Robyn C. Thompson Mrs

Durban University of Technology, robynt@dut.ac.za

oludayo Olufolorunsho olugbara Prof

Durban University of Technology, oludayoo@dut.ac.za

Alveens Singh Dr.

Durban University of Technology, alveens@dut.ac.za

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Deriving critical success factors for implementation of enterprise resource planning systems in higher education institution

Research Paper

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Robyn C. Thompson
Durban University of Technology
robymt@dut.ac.za

Oludayo Olufolorunsho Olugbara
Durban University of Technology
oludayoo@dut.ac.za

Alveens Singh
Durban University of Technology
alveens@dut.ac.za

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ABSTRACT

This paper presents the findings of a study that uses the advanced impact analysis (ADVIAN®) method to derive critical success factors (CSFs) of enterprise resource planning implementation in higher education institution. Through analysis of CSFs, the paper contributes towards assisting higher education institution to reduce some of the plethora of challenges in this domain as highlighted in the literature. The ADVIAN® method classified 20 factors into categories of integration, criticality and stability as well as ranked them by measures of precarious, driving and driven. The results of the classification and ranking show 5 factors that are ideal for intervening activities and 5 factors that should be observed as indicators of successful interventions. Eventually, 12 CSFs were found that provide managers of higher education institution with a reference point to improve ERP implementation.

Keywords (Required)

Enterprise resource, higher education, impact analysis, preference list, success factor

INTRODUCTION

The higher education institution (HEI) in developing nations of the world often face the dual challenges of rising operational costs and increasing difficulty to secure stable sources of income. Simultaneously, HEIs worldwide are under intense pressure from different stakeholders to offer quality services to more prospective citizens seeking higher education. To address these challenges, the HEI has long relied upon the computing systems to seamlessly support and streamline the various areas of its complex processes. These computing systems fall within the category of enterprise resource planning (ERP) system which is

defined as a technology that provides a unified business functions by integrating the core processes of an organization (Mutongwa & Rabah, 2013). An important objective of ERP implementation in HEI is to seamlessly support and integrate diverse administrative functions into a more systematic and cost-effective approach to gain strategic advantages (Rabaai, 2009; Ghuman & Chaudhary, 2012).

However, the implementation of ERP systems can be highly complex and expensive in terms of the total cost of procurement, maintenance, update, infrastructure, training, consultation and it is a difficult decision to adopt it (Mushavhanamadi & Mbohwa, 2013; Tobie, Etoundi & Zoa, 2016). Moreover, it is time consuming and generally appears to be a complex software engineering endeavor requiring a team of highly experienced engineers to provide support (Beatty & Williams, 2006). Specifically, the implementation of ERP systems within the African countries faces stern difficulties because of their specific context and how to implement these systems within the African context (Tobie et al. 2016). Concomitantly, the failure rate of ERP implementation is high (Xu, Yu, Lim & Hock, 2010; Kalema, Olugbara & Kekwaletswe, 2014; Abdelghaffar, 2012) with many exceeding budget and schedule (Chang, 2004; Grabski, Leech & Schmidt, 2011). The HEI is not exempted from the ERP implementation challenges (Kvavik 2002; Abugabah & Sanzogni, 2010) as a comprehensive literature review on ERP implementation has shown that the rate of failure in HEI is higher than in other sectors (AlQashami & Mohammad, 2015). Consequently, innovations to improve its success rate is a worthwhile quest and one that is largely lacking in large capacity research projects (Kvavik, 2002; Abugabah & Sanzogni, 2010; Ghuman & Chaudhary, 2012; Grabski, Leech & Schmidt, 2011; Abdelghaffar, 2012; AlQashami & Mohammad, 2015).

Consequently, with these gaps in mind and focusing on the student registration component of ERP systems, the objective of this study was to derive the critical success factors (CSFs) of ERP implementation in HEIs. The main reason we focus on ERP implementation for student registration is that the registration process intervenes with a number of other administrative processes such as student admission, accommodation and learning, academic records, tuition fees, course scheduling, and it involves a large user-base of faculty staff and students. This study, through the concept of CSFs, novel determination of cross impact matrix and application of the advanced impact analysis method, makes a unique contribution to the quantitative data analysis approach for deriving CSFs for ERP implementation. The results of this study could possibly serve as a reference point for managers of higher education in strategic decision making that relates to ERP implementation for student registration.

LITERATURE REVIEW

Despite the abundance of proposed best practices for ERP implementation, literature nonetheless illuminates an alarming number of failures (Abugabah & Sanzogni, 2010), and some have reported a failure rate in the range of 60% to 90% (Xu et al., 2010; Abdelghaffar 2012; Al-Shamlan & Al-Mudimigh, 2011). The overall success rate of ERP implementation was recently reported in a Doctoral thesis to be about 30% (Arthur, 2016). There are contentions that ERP implementation in a HEI is not satisfying all the desired functional requirements (Abugabah & Sanzogni, 2010). Shaul and Tauber (Shaul & Tauber, 2013) concluded that most failures stem from organizations too eagerly committing to ERP implementation without thorough investigation into the potential challenges and risks. It can be posited that the area of ERP implementation is in dire need of more contributions from quality research undertakings given the portrayal of ERP implementation in HEIs. Moreover, authors have reported the

lack of research studies examining successful implementation of ERP in HEI (AlQashami & Mohammad, 2015). Perhaps results stemming from different research approaches for identifying, classifying and ranking CSFs might redefine and cause a rethink of existing knowledge in this area. To this end, a good starting point may be a set of factors derived from the literature. What is required after this inference is a means of accurately deriving the necessary criteria for effective ERP implementation. In this study, it is our belief that the concept of CSFs adequately serves that purpose.

CSFs as a concept introduced by Rockart (1979) has been implemented in varying environments, including marketing and retail, management sciences, software management and public-private partnership projects. CSFs are essential for the success of any project, hence identifying and analyzing them according to their significance in creating value can help practitioners to adhere to the context of the project being developed (Almarri & Boussabaine, 2017). Moreover, CSFs can help to direct the efforts and resources of a project team in important areas leading to achieving the project objectives (Almarri & Boussabaine, 2017). A fair amount of research centers on CSFs of ERP implementation, but there appears to be very few frameworks that can easily mesh with the business processes in HEI and act as a reliable guide for ERP implementation (Hedman, 2010). Nah and Delgado (2006) conducted a comprehensive literature review to identify 7 categories of CSFs for ERP implementation. Finney and Corbett (2007) reviewed 45 articles to discover 26 CSFs using the content analysis technique. In another study, 19 factors were determined to be critical using literature review approach (Upadhyay & Dan, 2008). After analyzing 95 articles published between 1999 and 2008, Dezdar and Sulaiman (2009) recommended 17 CSFs for ERP implementation. An extensive review of literature covering 341 articles revealed 94 CSFs in 20 dimensions (Shaul & Tauber, 2013).

The method based on literature review and case study research was used to identify 12 ERP CSFs that were categorized into strategic and tactical categories (Allen & Kern, 2001). Esteves and Pastor (2000) added to these findings using the grounded theory methodology to develop a unified model that incorporated 20 CSFs of ERP implementation. A case study research by Shanks (2000) revealed that only 11 factors were critical for ERP implementation. Categories relating to CSFs for ERP implementation were extended to include people, vendor and culture using the partial least squared technique to rank these factors (Zhang, Lee, Zhang & Banerjee, 2003). Somers and Nelson (2004) explored 111 organizations that had implemented ERP to discover 22 CSFs. Structural equation modelling technique was employed to ascertain relationships between CSFs, project implementation success and post-implementation performance (Ram, Corkindale & Wu, 2013). Parhizkar and Comuzzi (2017) implemented a framework for conducting the impact analysis of ERP post-implementation modifications.

The concept of CSFs has attracted the attention of researchers in recent time because of the transformation of ERP implementation from the business realm to the HEI (Al-Hadi & Al-Shaibany, 2017). Frimpon (2012) identified and classified 28 CSFs of ERP implementation in HEIs into 5 categories. The set of CSFs for e-learning implementation has been investigated using the living theory and descriptive research methods which revealed 7 factors (Odunaike, Olugbara & Ojo, 2013). Scoping review, expert judgement, principal component analysis and direct cross impact analysis methods were respectively used to identify, validate, rank and classify factors as critical, active, inert and reactive (Kalema et al., 2014). Al-Hadi and Al-Shaibany (2017) investigated whether ERP implementation in HEI will succeed by employing a set of factors. They discovered from multiple studies that ERP

implementation does not automatically translate to success. However, they concluded that ERP implementation should be guided by 8 CSFs that have tendency to enrich the efficiency of HEIs.

It is evident from the literature review that there is an immense potential for HEI to experience the many benefits that successful ERP implementation have to offer. However, ERP implementation appears to be a complex endeavor attracting many challenges with reported high number of failed attempts. Many researchers have used the concept of CSFs to identify factors for ERP implementation, but they mainly based their results on prior literature (Shaul & Tauber, 2013). A potential shortcoming reveals the pattern of repetition of citations and absence of robust empirical evidence to support factor criticality (Kalema et al., 2014). This has led some authors to stress a distressing absence in the use of analytical methods to identify CSFs for ERP implementation, calling for further studies to be undertaken that will consider the influence of indirect relationships among factors (Kalema et al., 2014). This study uses the advanced impact analysis method (Linss & Fried, 2009; Linss & Fried, 2010) to calculate the direct and indirect interrelations between the impact factors of ERP implementation and to classify these impact factors according to several measures to support further HEIs decisions and activities.

METHODOLOGICAL APPROACH

The methodology of this study consists of four essential stages which are identification of critical success factors, expert validation of critical success factors, determination of cross impact matrix, and cross impact analysis.

Identification of Critical Success Factors

The starting useful tool to identify CSFs for ERP implementation is the literature study through the scoping review. Content analysis was commissioned for a systematic review of research articles retrieved using search engines from the scholastic databases of Elsevier, IEEE, ACM, Springer, Web of Science and Google scholar. A total of 38 articles was analyzed with searches conducted on relevant words and phrases such as “ERP”, “enterprise resource planning”, “CSF”, “critical success”, “critical factor”, “success factor” and “ERP implementation”. A total of 94 factors was identified from the 38 articles analyzed and the factors were subsequently pruned to 20 exhibiting a citation frequency of five or above. Pruning the initial list of 94 factors to 20 factors through a citation frequency threshold is considered an important step to identify CSFs for further analysis.

Expert Validation of Critical Success Factors

This study uses the expert judgement approach (Kalema et al. 2014) to validate the 20 CSFs identified from the literature to ensure the contexture relevance of these factors. The participants were selected based on their expertise in the area of ERP implementation in HEI. This method has been supported by other researchers for its suitability in finding concrete information system CSFs (Soja, 2006; Ganesh & Mehta, 2010). The selection of experts was expedited in stringent adherence to the characteristics suggested by Kuusi (1999). This study engaged 10 experts (5 male and 5 female experts) who were identified as playing important roles in ERP implementation in the authors' University. The experts included key role players at the university as well as employees from the independent project

management company tasked with the development and implementation of ERP systems in the authors' university. The experts have an average of 8 years of experience working with Information Technology System (ITS) and Oracle ERP system for student's registration. The ITS uses the Oracle ERP system as the database management platform in the authors' university. In this study, 2 of the invited 12 experts who were from the management positions declined the invitation because of work commitments and their inability to use ERP systems for student registration. All data gathered from the 10 experts were usable and this number of experts is acceptable for the study (Kalema et al., 2014; Worrell, Di Gangi & Bush, 2013). Moreover, Parhizkar and Comuzzi (2017) involved a panel of 7 ERP experts for the evaluation of their tool.

The experts supplied data in the form of preference lists with the aid of the "csfsurvey" online survey tool (<http://csfsurvey.biz.ht/index.php>). After doing research into some of the freely available online survey tools such as Google forms, Survey Monkey and Qualtrics, it was apparent that these tools could not perform the required functionality of building preference lists which are important for this study. Due to the limitations of these freely available survey tools, we developed the online survey tool used by the experts to supply data and convert preference lists to cross impact matrix and vice versa. Figure 1 shows the survey tool that supports the experts to create preference lists as much as possible and to generate cross impact matrix. In the next section, we will provide a detailed discussion on preference lists and cross impact matrix.

Identifying Factors that are Critical for Online Registration

Below is a list of 20 factors that influence implementation of an online registration system. Drawing on your knowledge and expertise, please indicate how each factor impacts on another. This is done by creating as many factor chains as you think necessary. Each chain can have between 2 to 20 factors, with no factors repeated in a chain. Each chain is structured so that the first factor impacts on the second, and the second impacts on the third and so on. Note that the factor that has the most impact will be at position 1, with the strength of the impact reducing down the chain. An example might be: F6-F4-F10-F1 - this indicates that factor 6 has the largest impact on factor 4, which then has a lesser impact on factor 10, which then has a lower strength impact on factor 1.

Click on a factor code (F1, F2, F3 ... F20) to create a chain. Click on the X to Delete a Chain

| Factor Code | Factor Description |
|-------------|---|
| | Senior and top management support |
| F2 | Agreed upon objectives and goals for the system |
| F3 | Development and adherence to a detailed project plan with clear goals and objectives |
| F4 | System implementation strategy or approach |
| F5 | Skilled project leader or manager to lead the implementation team |
| F6 | Skilled project team |
| | Autonomous project team |
| F8 | Expert ERP consultant to guide the implementation process |
| F9 | Vendor that provides support, guidance and technical expertise |
| | Good understanding of the existing system (legacy system) and its business processes |
| F11 | Commitment to business process reengineering (business processes should be flexible to better accommodate the software) |
| F12 | Plan for the integration of the system with existing software. |
| F13 | Data management plan that ensures that data is migrated efficiently and accurately to the new system |
| | Institution wide communication |
| F15 | An institutional culture that is open to change |
| F16 | Change management program so that end users have been prepared for any changes that might take place |
| F17 | End user involvement throughout the system implementation |
| F18 | User training |
| F19 | Plan for testing and troubleshooting the system |
| | Post implementation evaluation, to assess whether the goals and objectives of the project have been met. |

Chain History for: USR01

X F1>F4>F8>F10>F12>F14
X F16>F5>F18>F2>F9>F13

Current Chain
F20>F7>F10>F1>F14

Save Chain
Clear Chain

Figure 1: csfsurvey – an online survey tool for creating preference lists and cross impact matrix

Determination of Cross Impact Matrix

Cross Impact Analysis (CIA) heavily relies on Cross Impact Matrix (CIM) to numerically determine the impact of one factor on the others. The matrix is a square grid of dimensions equivalent to the number of impact factors squared. For effective analysis of the CIM, the number of factors should be limited to 40 (Heuer & Pherson, 2010) and experts usually fill out the matrix with impact scores or probability estimates to show the strength of the interrelationships between factor pairs (Mphahlele, Olugbara, Ojo & Kouriey, 2011). The assignment of an impact strength value to each factor pair forces the experts to be explicit regarding the relationships they believe are relevant (Schlange & Juttner, 1997). However, from our point of view, a limitation of the traditional CIM is the need for experts being familiar with all the factors and having the understanding of all them. In general, there only exist 4 impact strength scoring options with no option for experts to indicate that they are unsure of the impact score between factor pairs. Moreover, another major limitation of the analysis method is the number of pairwise comparisons that participants are required to evaluate (Heuer & Pherson, 2010). Previous authors have alluded that it is a painstaking exercise and burden to fill out CIM, whether carried out by a working committee, experts in interviews, or in specialized studies (Heuer & Pherson, 2010; De Jouvenel, 2000).

In this paper, we propose a novel preference lists approach that is eventually incorporated into the CIA process to fix the burden of having to fill out CIM. A preference lists is an organization of a set of factors in order of factor preferences so that a factor impacts on every other factor that is listed after it. The use of the preference lists approach has eliminated the need for participants or experts to fill out a 20 x 20 matrix for instance. Therefore, it reduced the time required by participants to explicitly supply impact scores. The impact strength of an ordered pair of factors is rather determined by the total number of preference relations received by the ordered pair. This has eliminated much intrinsic subjectivity and made CIM generation much pleasant. The impact scores computed automatically from the preference lists are used to populate the CIM which is normalized by dividing each entry of the matrix by the highest total impact score. The normalization is important to ensure that the resulting CIM is consistent with those obtained using the traditional scoring approach. This approach has also extended the impact analysis to a very large set of factors and allowed the opinion of an individual member of a large team of experts to count. The survey tool (Figure 1) implements an algorithm that converts preference lists to CIM and vice versa. The full proof of the algorithm is available in the public drop box file accessible from the link (using the password MICT01): (https://www.dropbox.com/s/aw3as4iam2xjy7/R_Thompson_mast_add_doc.pdf?dl=0).

An illustrative numerical example is considered to explain the application of the proposed preference lists approach to enhance CIA. Suppose an expert responded to the CIA evaluation by creating 3 preference lists {F1, F3, F2}, {F2, F4} and {F3, F1, F2, F10} from a set of 10 factors {F1, F2, ..., F10}. This response implies that F1 impacts on F3 and F2; F2 impacts on F4; F3 impacts on F1, F2 and F10. From the preference lists, 3 sets of preference relations {(F1, F3), (*F1, F2*), (*F3, F2*)}; {(F2, F4)} and {(F3, F1), (*F3, F2*), (F3, F10), (*F1, F2*), (F1, F10), (F2, F10)} are created. The total number of preference relations on a set of “n” factors is given by $(n^2 - n)/2$, $n > 1$. In the numeral example, the ordered pairs (italics pairs) (F1, F2) and (F3, F2) received a total impact score of 2 each because they appear twice in the preference relations, while the other pairs (not italics pairs) received a total impact score of 1 each because they appear once.

Table 1: Cross impact matrix corresponding to the illustrative example

| Factor | F1 | F2 | F3 | F4 | F5 | F6 | F7 | F8 | F9 | F10 |
|--------|----|----|----|----|----|----|----|----|----|-----|
| F1 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| F2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| F3 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| F4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| F5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| F6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| F7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| F8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| F9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| F10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Cross Impact Analysis

This study uses the advanced impact analysis (ADVIAN®) method (Linss & Fried, 2009; Linss & Fried, 2010) for cross impact analysis. The impact analysis supports an organization to explore the current challenges and prepare decisions in a more participatory manner for future endeavors. It is widely used within future research and scenario techniques to map the relationships of intangible and tangible resources within performance measurements as well as to investigate the relationship between impact factors and infer conclusions as to which impact factors are the most important to influence the whole system (Linss & Fried, 2009). There are other impact analysis methods such as the paper computer (Vester, 1987), MICMAC (Duperrin & Godet, 1973) and Fuzzy approach (Asan, Bozdog & Polat, 2004) for CIA. The main advantage of the ADVIAN® over other methods is that it does not depend on a 2-dimensional grid system for placing variables according to their active and passive sums (Guertler & Spinler, 2015). Moreover, the method gives the capability of calculating additional measures such as “integration”, “criticality” and “stability” for each factor and ranking of factors in terms of the measures of “driven”, “driving” and “precarious” is all included (Linss & Fried, 2010). The method makes use of the CIM filled out with impact strengths of 0 (no impact), 1 (weak or low impact), 2 (average or medium impact) or 3 (high or strong impact) (De Jouvenel, 2000; Linss & Fried, 2009), but other positive impact strengths can be used (Cole, Allen, Kilvington, Fenemor & Bowden, 2007). The formulae for calculating the parameters of the analysis method are succinctly given in Table 2.

FINDINGS OF THE STUDY

Table 3 shows the success factors identified from the literature, where it can be seen that senior and top management support (F1) received the highest citations of being critical (63.2%), while post-implementation evaluation (F20) received the lowest citations of being critical (13.1%).

Table 4 shows the normalized CIM generated from the preference lists collected from experts using the “csfsurvey” online survey tool that was developed in this study.

Table 2: Formulae for calculating parameters of the ADVIAN® (Linss & Fried, 2010; Guertler & Spinler, 2015)

| Parameter | Description | Formula |
|-------------------------------|--|---|
| Direct active sum | Sum of all impact strength values for factor f . It is an indication of how the factor acts on the system. | $dAS(f) = \sum_{a=1}^n (F_{fa})$ |
| Direct passive sum | Sum of all impact strength values on factor f . It is an indication of how the factor is affected by other factors. | $dPS(f) = \sum_{a=1}^n (F_{af})$ |
| Active sum | Sum of all impact strength values for factor f for order k . | $dAS_k(f) = \sum_{a=1}^n (F_{fa} * dAS_{k-1}(a))$ |
| Passive sum | Sum of all impact strength values on factor f for order k . | $dPS_k(f) = \sum_{i=1}^n (F_{if} dPS_{k-1}(i))$ |
| Indirect active sum | Sum of all indirect impact strength values for factor f up to order k . | $iAS(f) = \sum_{k=1}^n (dAS_k(f))$ |
| Indirect passive sum | Sum of all indirect impact strength values on factor f up to order k . | $iPS(f) = \sum_{k=1}^n (dPS_k(f))$ |
| Relative direct active sum | Direct active sum of factor f converted to a relative value with a maximum of 100. | $dAS'(f) = \frac{100dAS(f)}{\max_{f=1}^n \{dAS(f); dPS(f)\}}$ |
| Relative direct passive sum | Direct passive sum of factor f converted to a relative value with a maximum of 100. | $dPS'(f) = \frac{100dPS(f)}{\max_{f=1}^n \{dAS(f); dPS(f)\}}$ |
| Relative indirect active sum | Indirect active sum of factor f converted to a relative value with a maximum of 100. | $iAS'(f) = \frac{100iAS(f)}{\max_{f=1}^n \{iAS(f); iPS(f)\}}$ |
| Relative indirect passive sum | Indirect passive sum of factor f converted to a relative value with a maximum of 100. | $iPS'(f) = \frac{100iPS(f)}{\max_{f=1}^n \{iAS(f); iPS(f)\}}$ |
| Criticality | Criticality of factor f is the geometric mean of the relative indirect active sum and relative indirect passive sum. | $C(f) = \sqrt{iAS'(f) * iPS'(f)}$ |
| Integration | Integration of factor f into the whole system is the arithmetic mean of the relative active and passive sums. | $I(f) = \frac{iAS'(f) + iPS'(f)}{2}$ |
| Stability | Stability of factor f is calculated by subtracting the harmonic mean of relative indirect active sum and relative indirect passive sum from 100. | $S(f) = 100 - \left(\frac{2}{\frac{1}{iAS'(f)} + \frac{1}{iPS'(f)}} \right)$ |
| Precarious | Precarious value of factor f is the harmonic mean of the relative indirect active sum and criticality. | $P(f) = \sqrt{C(f) * iAS'(f)}$ |
| Driving | Driving value for factor f is the geometric mean of the active sum and 100-criticality. It is non-critical with high active sum. | $D(f) = \sqrt{(100 - C(f)) * iAS'(f)}$ |
| Driven | Driven value for factor f is the geometric mean of the passive sum and 100-criticality. It is non-critical with high passive sum. | $T(f) = \sqrt{(100 - C(f)) * iPS'(f)}$ |

Table 3: Success factors with citation frequency and percentage statistics

| Factor | Description | Frequency | Percentage |
|----------|--|-----------|------------|
| F1 (1) | Senior and top management support | 24 | 63.2% |
| F2 (2) | Project Plan with clear agreed upon objectives and goals | 19 | 50.0% |
| F3 (3) | Project management to implement the project plan | 21 | 55.3% |
| F4 (4) | ERP strategy and implementation methodology | 11 | 29.0% |
| F5 (5) | Project leader | 15 | 39.5% |
| F6 (6) | Skilled project team | 20 | 52.6% |
| F7 (7) | Autonomous project team | 9 | 23.7% |
| F8 (8) | Expert ERP consultant | 13 | 34.2% |
| F9 (9) | ERP Vendor support and guidance | 11 | 29.0% |
| F10 (10) | Legacy system and business processes | 11 | 29.0% |
| F11 (11) | Business process reengineering and minimal customization | 16 | 42.1% |
| F12 (12) | Software integration | 13 | 34.2% |
| F13 (13) | Data management | 9 | 23.7% |
| F14 (14) | Effective organization wide communication | 18 | 47.4% |
| F15 (15) | Organizational culture | 9 | 23.7% |
| F16 (16) | Change management | 18 | 47.4% |
| F17 (17) | User involvement throughout implementation | 13 | 34.2% |
| F18 (18) | User training | 17 | 44.7% |
| F19 (19) | Software testing and troubleshooting | 10 | 26.3% |
| F20 (20) | Post-implementation evaluation | 5 | 13.1% |

Table 4: Normalized cross impact matrix of 20 success factors

| Factor | F1 | F2 | F3 | F4 | F5 | F6 | F7 | F8 | F9 | F10 | F11 | F12 | F13 | F14 | F15 | F16 | F17 | F18 | F19 | F20 |
|--------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 1 | 0 | 0.5 | 0.7 | 0.5 | 0.7 | 0.6 | 0.4 | 0.3 | 0.5 | 0.4 | 0.5 | 0.4 | 0.5 | 0.8 | 0.7 | 0.6 | 0.7 | 0.6 | 0.6 | 0.6 |
| 2 | 0.1 | 0 | 0.4 | 0.6 | 0.2 | 0.2 | 0.1 | 0.2 | 0.1 | 0.5 | 0.2 | 0.4 | 0.5 | 0.4 | 0.4 | 0.4 | 0.7 | 0.7 | 0.6 | 0.7 |
| 3 | 0 | 0.1 | 0 | 0.5 | 0.4 | 0.3 | 0.2 | 0.2 | 0 | 0.3 | 0.3 | 0.4 | 0.6 | 0.4 | 0.4 | 0.6 | 0.6 | 0.6 | 0.5 | 0.4 |
| 4 | 0.1 | 0 | 0 | 0 | 0.3 | 0.2 | 0 | 0.3 | 0.2 | 0.5 | 0.2 | 0.5 | 0.5 | 0.3 | 0.3 | 0.4 | 0.4 | 0.7 | 0.5 | 0.5 |
| 5 | 0.1 | 0.2 | 0.1 | 0.3 | 0 | 0.8 | 0.4 | 0.2 | 0.3 | 0.5 | 0.2 | 0.5 | 0.4 | 0.5 | 0.5 | 0.6 | 0.5 | 0.6 | 0.6 | 0.4 |
| 6 | 0 | 0.1 | 0.1 | 0.2 | 0 | 0 | 0.4 | 0.2 | 0.4 | 0.4 | 0.2 | 0.4 | 0.3 | 0.4 | 0.4 | 0.5 | 0.4 | 0.5 | 0.6 | 0.3 |
| 7 | 0 | 0.1 | 0.1 | 0.2 | 0.1 | 0.2 | 0 | 0.1 | 0.2 | 0.3 | 0.2 | 0.4 | 0.3 | 0.3 | 0.3 | 0.5 | 0.3 | 0.3 | 0.4 | 0.2 |
| 8 | 0 | 0.1 | 0.1 | 0.2 | 0.2 | 0.1 | 0.1 | 0 | 0.2 | 0.6 | 0.4 | 0.7 | 0.6 | 0.2 | 0.2 | 0.3 | 0.4 | 0.5 | 0.5 | 0.6 |
| 9 | 0 | 0.4 | 0.4 | 0.4 | 0.2 | 0.2 | 0.1 | 0.1 | 0 | 0.4 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.4 | 0.5 | 0.6 | 0.4 |
| 10 | 0 | 0.1 | 0.1 | 0.2 | 0 | 0.1 | 0 | 0.1 | 0.2 | 0 | 0.5 | 0.9 | 0.6 | 0.3 | 0.4 | 0.5 | 0.6 | 0.8 | 0.9 | 0.7 |
| 11 | 0 | 0.1 | 0.1 | 0.2 | 0.1 | 0.1 | 0 | 0 | 0.1 | 0.1 | 0 | 0.6 | 0.6 | 0.5 | 0.5 | 0.5 | 0.5 | 0.6 | 0.7 | 0.6 |
| 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.8 | 0.3 | 0.4 | 0.7 | 0.6 | 0.6 | 0.9 | 0.7 |
| 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 | 0 | 0 | 0 | 0.1 | 0 | 0.2 | 0.2 | 0.5 | 0.6 | 0.6 | 0.7 | 0.7 |
| 14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 | 0 | 0.5 | 0.6 | 0.7 | 0.6 | 0.3 | 0.5 |
| 15 | 0.1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 | 0 | 0.1 | 0.5 | 0 | 0.5 | 0.6 | 0.5 | 0.4 | 0.6 |
| 16 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 | 0 | 0.1 | 0 | 0 | 0.1 | 0 | 0.2 | 0 | 0.8 | 0.7 | 0.9 | 0.7 |
| 17 | 0 | 0 | 0 | 0.1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 | 0.2 | 0 | 1 | 0.5 | 0.7 |
| 18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 | 0.2 | 0.2 | 0 | 0.5 | 0.7 |
| 19 | 0 | 0 | 0 | 0.1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 | 0.1 | 0.1 | 0.4 | 0.4 | 0 | 0.9 |
| 20 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 | 0 |

Direct with Indirect Relationships

The results pertaining to the direct and relative active, passive sums and relative indirect active and passive sums are presented in Table 5. The active sum demonstrates the degree to which a factor has direct impact on the system, while the passive sum indicates the degree to which a factor is affected by the system. It appears that F1 has the highest impact (97.25) on other factors while F5 and F2 have a high direct influence on the system with active sums of 70.64 and 67.89 respectively. The factors with high passive sums are directly influenced by the system. These being F20 with a value of 100, F18 and F19, both with passive sums of 99.08 each. The indirect active and passive sums are calculated up to order 19 which is one less the number of factors. They show the interrelationships that exist and how factors may impact on the ERP system. The focus of this paper is on factors exceeding the average by two-thirds of the standard deviation as highlighted in the table following the suggestion by Guertler and Spinler (2015).

Table 5: Direct and indirect active and passive sums

| Factor | Active Sum (<i>dAS</i>) | Passive Sum (<i>dPS</i>) | Relative Direct Active Sum (<i>dAS'</i>) | Relative Direct Passive Sum (<i>dPS'</i>) | Relative Indirect Active Sum (<i>iAS'</i>) | Relative Indirect Passive Sum (<i>iPS'</i>) |
|-----------------------------------|------------------------------|-------------------------------|---|--|---|--|
| 1 | 10.6 | 0.4 | 97.25 | 3.67 | 80.74 | 1.61 |
| 2 | 7.4 | 1.7 | 67.89 | 15.60 | 43.04 | 2.29 |
| 3 | 6.8 | 2.1 | 62.39 | 19.27 | 37.90 | 2.55 |
| 4 | 5.9 | 3.5 | 54.13 | 32.11 | 32.20 | 9.50 |
| 5 | 7.7 | 2.2 | 70.64 | 20.18 | 48.58 | 3.22 |
| 6 | 5.8 | 2.8 | 53.21 | 25.69 | 31.28 | 3.91 |
| 7 | 4.5 | 1.7 | 41.28 | 15.60 | 25.23 | 2.05 |
| 8 | 6.0 | 1.9 | 55.05 | 17.43 | 31.46 | 5.04 |
| 9 | 5.9 | 2.2 | 54.13 | 20.18 | 39.00 | 3.66 |
| 10 | 7.0 | 4.1 | 64.22 | 37.61 | 25.40 | 8.03 |
| 11 | 5.9 | 3.1 | 54.13 | 28.44 | 20.67 | 6.19 |
| 12 | 5.0 | 5.6 | 45.87 | 51.38 | 7.75 | 11.47 |
| 13 | 3.7 | 6.3 | 33.95 | 57.80 | 5.88 | 16.55 |
| 14 | 3.3 | 5.5 | 30.28 | 50.46 | 5.01 | 17.61 |
| 15 | 3.4 | 6.0 | 31.19 | 55.05 | 8.14 | 25.06 |
| 16 | 3.7 | 8.0 | 33.95 | 74.31 | 5.83 | 37.83 |
| 17 | 2.6 | 9.4 | 23.85 | 86.24 | 3.39 | 56.44 |
| 18 | 1.7 | 10.8 | 15.60 | 99.08 | 1.69 | 72.65 |
| 19 | 2.1 | 10.8 | 19.27 | 99.08 | 2.91 | 70.55 |
| 20 | 0.1 | 10.9 | 0.92 | 100.00 | 0.12 | 100.00 |
| Avg | | | 45.46 | 45.41 | 22.81 | 22.81 |
| Std Dev | | | | | 20.82 | 29.10 |
| Avg + $\frac{2}{3}$ of Std Dev | | | | | 36.69 | 42.21 |

Due to the average relative direct active and passive sums being virtually equal (45.46 and 45.41 respectively) and average relative indirect active and passive sums (22.81) being equal, it seems that

these factors directly and indirectly affect the system to the same degree that the factors are affected by the system. It was also apparent from changes in average relative active and passive sums across the orders that strong interrelationships exist between the factors. With the average relative direct active and passive sums at order 1 being 45, but this moving to an average of 23 for both the relative indirect active and passive sums at order 20. The impact strength that the factor has on the system and on other factors diminishes with the increasing orders.

The factor F1 exerts the most influence on other factors with a relative indirect active sum of 80.7, having the strongest effect (impact values of 0.7 or 0.8 in Table 4) on F14, F3, F5, F15 and F17. Therefore, F1 has a significant direct effect on successful ERP implementation. F5, F2, F9 and F3 with relative indirect active sums of 48.6, 43, 39 and 37.9 respectively, although not as significant as F1, have an impact on other factors. F2 and F3 have strong impacts on F17 and F18. F2 also has a marked effect on F20, with an interrelation existing between these factors. F3 has notable interrelations with other plans, these being F13 and F16. Another interrelationship that exists is between F5 and F6. Finally, F9 has a high relative indirect active sum with highest impact on F19, indicating that the selection of the correct vendor (F9) influences the testing and troubleshooting of the system (F19). High indirect passive sums are identified with regard to passivity for F20, F18, F19, and to a lesser extent F17. The strongest impact on F20 is exerted by F19. F18 and F19 are both highly reactive to F10. In addition, F12 and F16 impact highly on F19 with F16 exerting a high impact on F17. However, the strongest passive interrelationship that exists between two factors is the impact that user involvement throughout implementation (F17) has on user training (F18).

Classification of Factors by Measures of Criticality, Integration and Stability

The conditional state of the system of factors can be determined by criticality, integration and stability. Table 6 presents a summary of these values based on the formula in Table 2.

The changes that may occur in a *critical* factor can have significant effects on the system which could result in large scale changes. None of the success factors present high criticality but the most critical factors are F4, F16, F19, F15, F10 and F17 (Figure 2).

The *integration* of a factor indicates the strength of its connection with other factors and the system. Higher levels of integration could present feedback loops. Factors with the highest integration are F20 (50.1), F1 (41.17), F18 and F19 (Figure 3). There appears to be mutual connections between F18 and F19, with F18 impacting on F19 and F19 impacting on F18. Indirect feedback loops could also exist with F4 having a mutual connection through F1. But these feedback loops are not strong, and they are controllable, this being evident by the system stability.

A system of factors is considered *stable* if the factors are closed to the axes of the passive and active sums. That is, there exist factors that control the system and factors that are controlled by the system. When this occurs feedback loops that possibly exist will be controllable (Linss & Fried, 2010). A high system stability of 92.78 was achieved, indicating that the system of factors is stable. Factors contributing most to the system stability with high active sums compared to their passive sums are F1, F7, F2 and F3 (Figure 4). F20 and F18 also contribute to the system stability with high passive and low active sums. F7, along with a high stability has a low integration value of 13.64 (Table 6), indicating that

the factor can hardly be altered by other factors in the system and seems independent of changes that occur in other factors. It should be noted that every factor has a stability value above 85.3.

Table 6: Classification of success factors

| Factor | Classification | | |
|-----------------------------|----------------|-------------|-----------|
| | Criticality | Integration | Stability |
| 1 | 11.40 | 41.17 | 96.84 |
| 2 | 9.92 | 22.66 | 95.66 |
| 3 | 9.84 | 20.23 | 95.22 |
| 4 | 17.49 | 20.85 | 85.33 |
| 5 | 12.51 | 25.90 | 93.96 |
| 6 | 11.06 | 17.60 | 93.05 |
| 7 | 7.20 | 13.64 | 96.20 |
| 8 | 12.59 | 18.25 | 91.31 |
| 9 | 11.95 | 21.33 | 93.31 |
| 10 | 14.28 | 16.72 | 87.80 |
| 11 | 11.31 | 13.43 | 90.47 |
| 12 | 9.43 | 9.61 | 90.75 |
| 13 | 9.87 | 11.22 | 91.32 |
| 14 | 9.39 | 11.31 | 92.20 |
| 15 | 14.28 | 16.60 | 87.71 |
| 16 | 14.84 | 21.83 | 89.90 |
| 17 | 13.82 | 29.91 | 93.61 |
| 18 | 11.07 | 37.17 | 96.70 |
| 19 | 14.34 | 36.73 | 94.40 |
| 20 | 3.42 | 50.06 | 99.77 |
| Average | 11.50 | 22.81 | 92.76 |
| Std Dev | 3.07 | 10.98 | 3.55 |
| AVG + $\frac{2}{3}$ Std Dev | 13.55 | 30.13 | 95.15 |
| SYSTEM STABILITY | | | 92.78 |

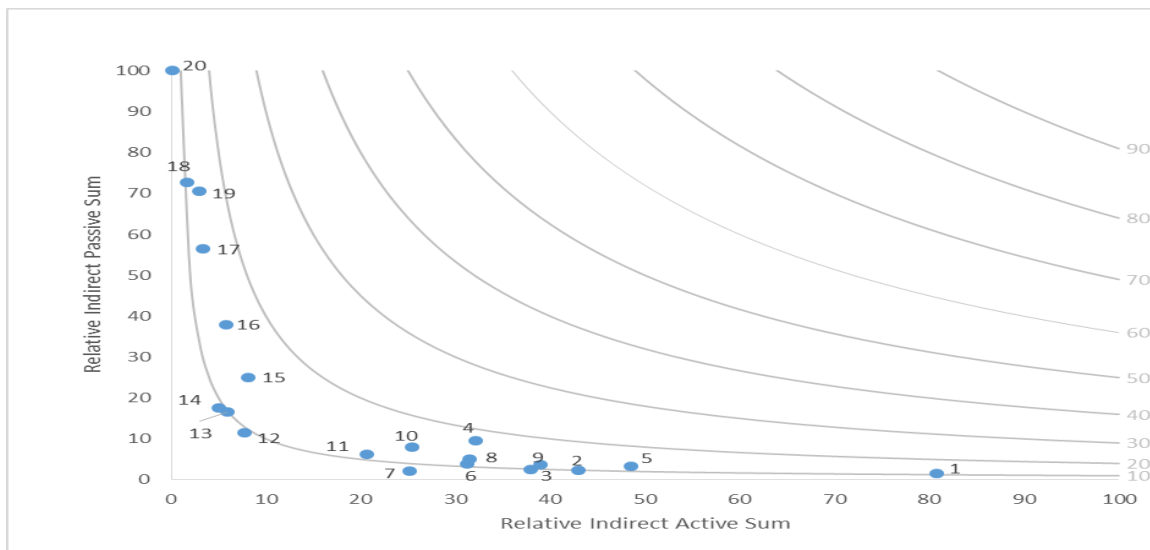


Figure 2: Criticality of success factors

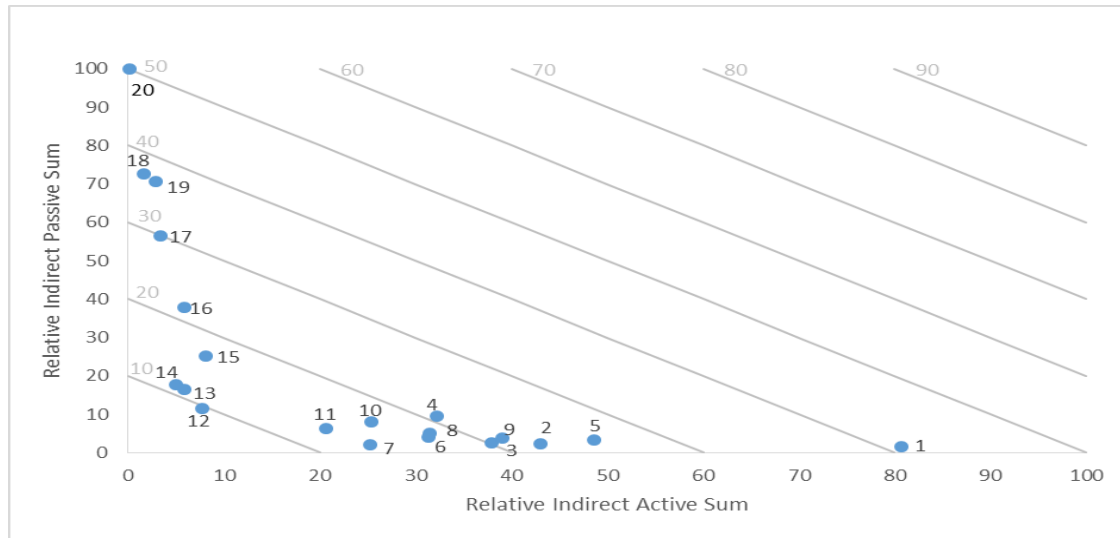


Figure 3: Integration of success factors

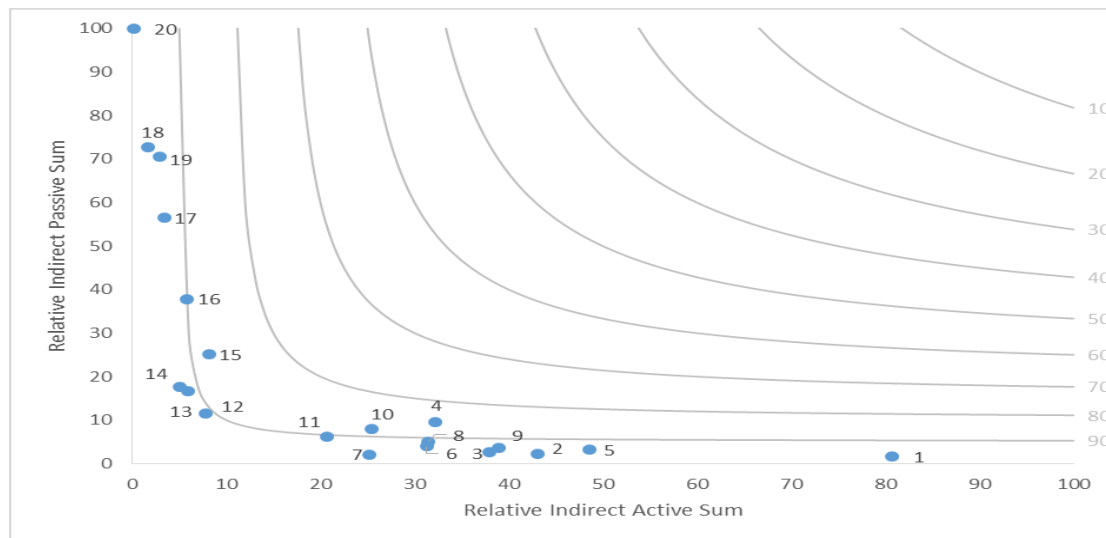


Figure 4: Stability of success factors

Ranking of Factors by Measures of Precarious, Driving and Driven

The ranking of factors is done according to three essential measures which are precarious, driving and driven (Table 7). The first category provides a value for the ranking of *precarious* impact factors, with a high value indicating that the factor is not affected by external elements but rather exerts most influence on the system. Due to the existence of low criticality values and precarious value being calculated in terms of criticality, low precarious values have presented themselves, with the highest being 30.34. The most precarious factors in the system are F1, F2, F4, F5, F8 and F9 (Table 7 and Figure 5), but they may not be ideal for intervening activities because of their low precarious rating and low criticality.

Table 7: Ranking of critical success factors

| Factor | Ranking of Factors | | | | | |
|-----------------------------|--------------------|--------------------|---------|-----------------|--------|----------------|
| | Precarious | Precarious Ranking | Driving | Driving Ranking | Driven | Driven Ranking |
| 1 | 30.34 | 1 | 84.58 | 1 | 11.94 | 20 |
| 2 | 20.66 | 5 | 62.26 | 3 | 14.35 | 18 |
| 3 | 19.31 | 7 | 58.46 | 5 | 15.17 | 17 |
| 4 | 23.73 | 3 | 51.54 | 8 | 27.99 | 10 |
| 5 | 24.65 | 2 | 65.19 | 2 | 16.79 | 16 |
| 6 | 18.60 | 9 | 52.74 | 6 | 18.65 | 14 |
| 7 | 13.48 | 11 | 48.39 | 9 | 13.80 | 19 |
| 8 | 19.90 | 6 | 52.44 | 7 | 20.99 | 13 |
| 9 | 21.59 | 4 | 58.60 | 4 | 17.95 | 15 |
| 10 | 19.05 | 8 | 46.66 | 10 | 26.24 | 11 |
| 11 | 15.29 | 10 | 42.82 | 11 | 23.43 | 12 |
| 12 | 8.55 | 14 | 26.50 | 12 | 32.23 | 9 |
| 13 | 7.62 | 15 | 23.02 | 14 | 38.63 | 8 |
| 14 | 6.86 | 16 | 21.31 | 16 | 39.94 | 7 |
| 15 | 10.78 | 12 | 26.42 | 13 | 46.34 | 6 |
| 16 | 9.30 | 13 | 22.27 | 15 | 56.75 | 5 |
| 17 | 6.84 | 17 | 17.08 | 17 | 69.74 | 4 |
| 18 | 4.32 | 19 | 12.25 | 19 | 80.38 | 2 |
| 19 | 6.46 | 18 | 15.80 | 18 | 77.74 | 3 |
| 20 | 0.63 | 20 | 3.36 | 20 | 98.27 | 1 |
| AVG | 14.40 | | 39.58 | | 37.37 | |
| Std Dev | 8.01 | | 21.66 | | 25.93 | |
| AVG + $\frac{2}{3}$ Std Dev | 19.74 | | 54.03 | | 54.66 | |
| AVG - $\frac{2}{3}$ Std Dev | 9.06 | | | | | |

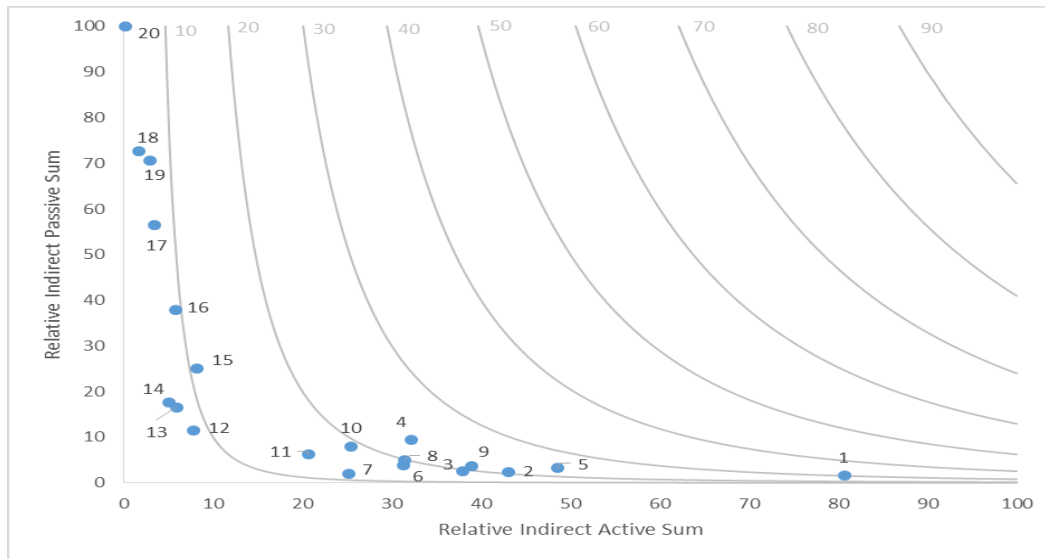


Figure 5: Ranking of precarious factors

The success of ERP implementation can be improved by controlling factors demonstrating a high *driving* ranking, as they have a high influence on other factors and do not cause any strong feedback. F1, F5, F2, F3 and F9 appear to be the factors that can drive a successful ERP implementation (Figure 6).

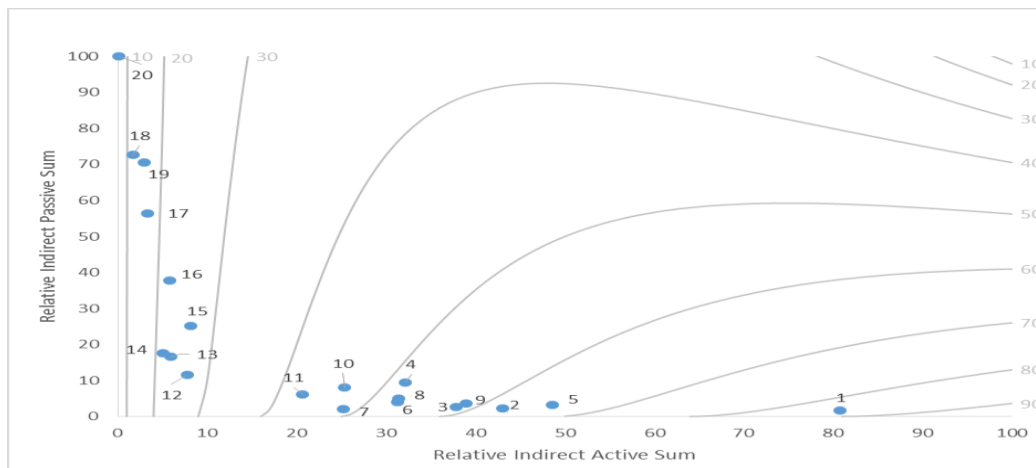


Figure 6: Ranking of driving factors

Driven factors are more reactive in nature as they are non-critical factors with high passive sums. These factors can be used as indicators of the impact that an external intervention has on ERP implementation success. From Table 7 and Figure 7, factors F20, F18, F19, F17 and F16 are the most driven factors and will be the most affected by external changes made.

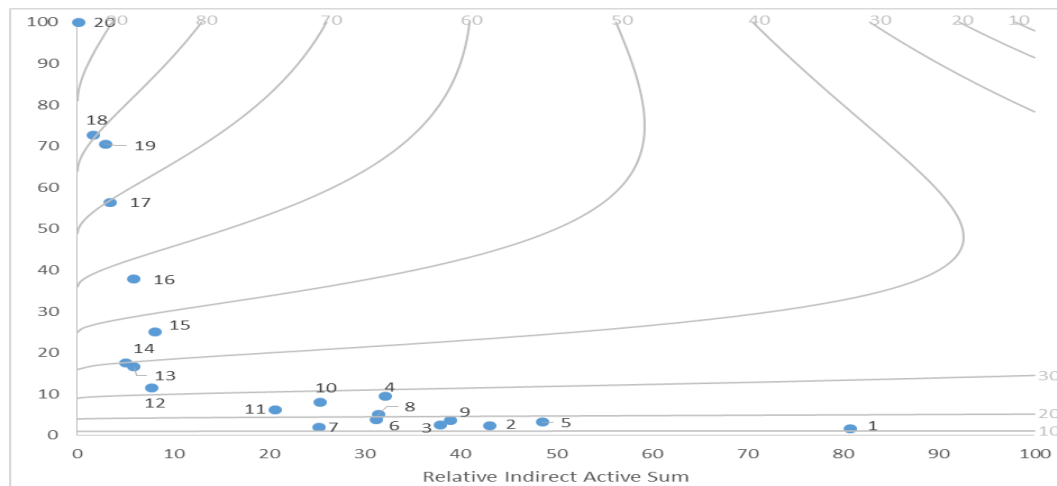


Figure 7: Ranking of driven factors

INTERPRETATION OF FINDINGS

A deliberation on each CSF for its contribution to the discourse of ERP implementation in HEI is provided in this section.

- (a) *ERP vendor support and guidance (F9)*: data analysis illuminates this factor to present a high activity because it is ranked high on the driving scale and has a low precarious value. This indicates that the factor has the ability to influence other factors in the system and is therefore driving in nature.
- (b) *Expert ERP consultant (F8)*: the factor does not establish itself firmly in any of the classifications studied. Consequently, it does not appear to have a major impact on the success or failure of ERP implementation. The low active sum of 31.46 indicates inability to influence the system and low passivity shows that it is not highly reactive to changes.
- (c) *Software integration (F12)*: low precarious value could establish the factor suitable for intervening activities, but the low driving value of 26.5 and low active sum of 7.75 show that it does not appear to be influential enough to be used for interventions.
- (d) *Software testing and troubleshooting (F19)*: this factor is one that is most influenced in the system with a passive sum of 70.55. The factor passivity is also evident with an integration value of only 36.7, low active sum (2.9) and minimal criticality (14.3). Being ranked third in the list of driven factors, the factor can be viewed as highly driven and one ideal for monitoring the effect of any intervention that is done on the system.
- (e) *User training (F18)*: the factor is established as highly influenced by other factors with a passive sum of 72.65. It has the highest driven ranking, establishing it as driven and ideal for monitoring the success of implementation interventions. This along with its low driving value, negates its possible inclusion as an influencing factor that was a possibility due to having a low precarious value. Although user training is identified as highly integrated, we think that the low integration value (37.17), high passivity and low activity, indicate that it does not have strong connections with other factors and should therefore not be deemed highly integrated.
- (f) *User involvement throughout implementation (F17)*: the factor appears to be neither active nor driving but it does emerge as being highly influenced by other factors and it is a driven factor. It

should be monitored when changes are made to the system to ascertain whether the changes have an effect on user involvement throughout implementation. The low precarious value indicates that the factor could be used for interventions, but due to the factor being highly reactive in nature, it is excluded. In addition, the analysis identifies this factor as critical with a low value of 13.8 but its criticality seems more akin to monitoring ERP implementation.

- (g) *Senior and top management support (F1)*: the findings mirror current literature in supporting this factor as critical factor for any ERP implementation. The factor is highly active (80.7), it ranks first according to driving factors (84.6) and it is one of the most stable factors within the system because of its closeness to the activity sum axis (96.8). It is a factor with a higher than average integration value (41.2) and it ranks high on the list of precarious factors (30.3). We agree with the first two discoveries, identifying the factor as highly active and driven. It is therefore ideal for use in intervening activities and eliminating it from being highly precarious, which indicates its unsuitability for intervention. Even though it emerges as a factor that may be highly integrated and one that contributes to the system stability, it is highly active, therefore influences other factors and is not influenced itself which is seen by the low passive sum of 1.6. It is a driving factor, therefore cannot be deemed a factor contributing to the system stability because any changes made to it will destabilise the system by affecting all other factors.
- (h) *Project plan with clear, agreed upon objectives and goals (F2)*: this study places this factor as the third most active for ERP implementation (activity sum 43), exerting the most impact on two factors in the user category. It is ranked third in driving factors, making it an ideal factor to be used when student registration needs intervention measures. The factor emerges as highly contributing to the stability of the entire system. Similar to other factors like senior and top management support and project management, the highly influential nature of the factor and lack of major influences acting on it, indicates its stabilising ability. Although it lies within the upper rankings of precarious, the low precarious value and its alignment with a driving factor eliminates it from the set of high precarious values.
- (i) *Effective institution wide communication (F14)*: this study did not find this factor noticeably important in any of the classifications besides it having a low precarious value, indicating its possible inclusion as a factor to be used for intervention. This finding is in sharp contrast to literature where it was positioned as a critical factor in about 50% of the papers reviewed. The discrepancy may be a result of the student registration system not affecting all stakeholders, nor does it affect the entire institution because it is only used by those that have direct involvement with student registration. Another reason for the discrepancy may be due to some articles not including a separate factor for user involvement throughout implementation, but rather having one factor called the organization's wide communication.
- (j) *Organizational culture (F15)*: despite being ranked third in criticality, the low value of 14.3 by no means identifies it as highly critical for ERP implementation success. It presents itself as having an effect on other factors by affecting 9 other factors and being affected by 18 factors. It might be advisable to use it as one to observe and if changes are seen in the factor, intervention may be necessary.
- (k) *Legacy system and business processes (F10)*: this factor did not present itself as highly relevant in any classifications besides criticality with the fifth highest value (14.3). Although not significant in terms of criticality, the factor impacts on 16 factors and is impacted on by 11 factors. It follows that although the strength of the impact is not high, this may be a factor to retain as being critical for and use it for monitoring changes. If changes occur to this factor during the ERP implementation, corrective action should be investigated.

- (l) *Project management to implement the project plan (F3)*: data analysis identifies this factor as having a high driving potential and places it fifth in activity levels indicating its high influence on other factors in the system, inclusive of user training and involvement, change management, and data management plans. We believe that if enough attention is not paid to this factor, this could result in a lack of focus on both user involvement throughout implementation and user training which ultimately could cause resistance to using the ERP software. This would have a negative effect on the implementation success. Moreover, the factor has a high stability value (95.2) therefore, contributing to the system stability.
- (m) *ERP strategy and implementation methodology (F4)*: from the findings, the importance of the ERP implementation strategy is recognized in terms of its criticality having the highest value of 17.5 and high precarious ranking. Due to the high precarious ranking and low activity value (32.2), the factor should not be used for intervention strategies as it exerts little influence on the system or on other factors. The higher criticality value identifies the factor as both acting on other factors and being acted on by other factors and should be observed for any changes that may occur.
- (n) *Business process re-engineering and minimal customisation (F11)*: this factor was posited in the literature as one of the most critical factors (Sumner, 1999; Shannks, Parr, Hu, Corbitt, Thanasankit & Seddon, 2000; Light, 2001). However, this is in sharp contrast to the findings of this study that did not identify it as a major factor in any of the classifications under investigation. What was established is that for ERP implementation, it is more a driving factor (42.8) than a driven factor (23.4) but it does not have a marked effect on the system as a whole.
- (o) *Change management (F16)*: this factor is observed as having a higher criticality (14.8) than other factors. But its significantly higher driven ranking (value of 56.7) and higher active sum compared to passive sums results in us rejecting it as a critical factor for student registration. It is rather recommended to be used as a driven factor for observing interventions that are implemented.
- (p) *Data management (F13)*: previous research alludes to the importance of this factor including plans for data conversion, accuracy, analysis and migration but this does not appear evident in the implementation of student registration. It reveals low activity and passivity values of 5.9 and 16.6 respectively, with the level of integration being a mere 11.2 and criticality having a value of 9.9. The factor does not present itself as being either driven (23) nor driving (38.7). The only value that is flagged is its lower precarious ranking being sixth from the bottom, indicating that it could be considered for intervention. Due to the driving value being only 23 and activity value being a mere 5.9, it does not conform to the values necessary for consideration as a driving factor.
- (q) *Project leader (F5)*: the importance of this factor as emphasized in the literature is consistent with the findings of this study where it was identified as having a high active sum (48.6) and is one of the main driving factors. It has the most influence on the skilled project team which could be due to the project leader influencing the selection, training, and motivation of the team. The factor is therefore ideal for intervention due to the influence the leader holds. We deem the high precarious value irrelevant due to the low criticality value.
- (r) *Skilled project team (F6)*: this factor exerts significant influence on user training as well as system testing and troubleshooting. Perhaps this is due to the team implementing the system being the same individuals that perform the user training as well as testing and troubleshooting. This study unveiled the high influence that the project leader has on the project team thus, any intervention implemented by the project leader should be evident in the project team. Although

this factor did not emerge as critical in any area, it was sixth in the ranking of driven factors, so it could possibly be considered for intervention if the need arises.

- (s) *Autonomous project team (F7)*: the factor is not remarkably driving nor driven with its low integration and criticality values. The only classification that needs to be mentioned is the level of stability (96.2) indicating that the factor contributes significantly to the stability of student registration. What is also noticeable is that due to it having low integration and passivity, it is the most stable during implementation and will not be affected by changes made to other factors during implementation.
- (t) *Post-implementation evaluation (F20)*: possibly due to this factor being an evaluation of the entire system success, it has emerged that it has little to no influence on any of the other factors. However, it has the highest passivity value indicating its ability to be influenced and therefore highly driven, such that any intervention that is imposed will or should be evident and result in a change to the post-implementation evaluation. It could be due to the high passivity that it emerges as having the highest integration, but for a factor to be strongly connected to others, both high passive and active sums need to exist, which is not the case. The low precarious ranking may indicate that it can be used for interventions, but its low activity and high passivity exclude the factor from this category. With a stability value of 99.8, caused by high passivity and low activity, it contributes significantly to the stability of ERP implementation.

Table 8 summarizes the 12 factors that we have identified to be critical for successful ERP implementation in HEI. Amongst these 12 CSFs, those ideal for intervening activities are the driving factors. The factors that should be observed as indicators of successful intervention are the driven factors.

Table 8: CSFs for ERP implementation in HEI

| FACTOR | Criticality | Driving | Driven |
|--|-------------|---------|--------|
| ERP vendor support and guidance | | ✓ | |
| Senior and top management support | | ✓ | |
| Project plan with clear agreed upon objectives and goals | | ✓ | |
| Project management to implement project plan | | ✓ | |
| Project leader | | ✓ | |
| Change management | | | ✓ |
| Post-implementation evaluation | | | ✓ |
| Software testing and troubleshooting | | | ✓ |
| User training | | | ✓ |
| User involvement throughout implementation | | | ✓ |
| Organizational culture | ✓ | | |
| ERP strategy and implementation methodology | ✓ | | |

CONCLUSION

The domain of this study is ERP implementation in HEI for student registration. The CSFs for ERP implementation in HEIs have been identified, validated, classified, and ranked. A review of current literature using content analysis was employed to develop a foundation for this study. Data in the form

of preference lists were collected from experts using the developed “csfsurvey” tool. It is apparent that all factors play important roles in the ERP implementation for student registration, but this study was aimed at determining which factors are most critical. The concept of criticality is highly subjective with the definition for this study being established as factors that influence the system and are highly influenced by other factors.

Even though an ERP in HEIs is an information system with student registration being an important module, there may be a margin of disparity that prevents the study results from being generalized to all implementations of information systems. The 20 CSFs gathered from the literature were taken to the field for validation. However, we acknowledge that numerous other research papers exist that may be relevant to this investigation, but because of time and space constraints, it was not possible to review all possible papers that may exist. The frequency of each factor may be slightly skewed as some of the articles reviewed only chose to look at one specific category of CSFs, while others presented CSFs in all categories. Both observations are noted as possible limitations of the study. With us choosing to use the ADVIAN® developed between the years 2005 to 2010, we were only able to identify a limited number of other studies referencing the method. However, the method may have inherent limitations because it has not yet been widely applied by other researchers. Maybe the inherent limitations of cross impact matrix which the preference lists approach has boldly addressed prohibited the wide application of the method. Hopefully, through the novel contribution of the preference lists approach, the method might become more popular in a short time to come.

Several areas of future research were uncovered during this study. This study should be extended to different institutions of higher education that have implemented ERP for student registration with this study being used as a springboard. The results of further studies would then validate the findings of this research. This would contribute greatly to the underserved area of ERP research. The current study focuses on ITS and Oracle ERP systems for student registration, but it would be prudent to extend the study methodology to CSFs for a variety of vendor products. This would serve to further generalize the findings across all ERP suites. What is paramount is a comparative study that compares the various factors that emerge as critical where different application modules of ERP are implemented.

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REFERENCES

- Mutongwa, M.S. & Rabah, K. (2013). ERP system solutions for small and medium enterprises in Trans Nzoia County–Kenya. *Journal of Emerging Trends in Computing and Information Sciences*, 4(11), 869-876.
- Rabaa'i, A. A. (2009, 15-17 December 2009). *Identifying critical success factors of ERP systems at the higher education sector*. Paper presented at the Third International Symposium on Innovation in Information & Communication Technology, Amman, Jordan.

- Ghuman, K., & Chaudhary, S. (2012, 26 - 28 March 2012). *Incorporation of ERP in educational institutions: an empirical study*. Paper presented at the International Conference on Technology and Business Management, Shanghai, China.
- Mushavhanamadi, K. & Mbohwa, C. (2013). The impact of enterprise resource planning system (ERP) in a South African Company. *International Journal of Social, Management, Economics and Business Engineering*, 7(11), 1624-1628.
- Tobie, A. M., Etoundi, R. A., & Zoa, J. (2016). A literature review of ERP implementation within African countries. *The Electronic Journal of Information Systems in Developing Countries*.
- Beatty, R.C. & Williams, C.D. (2006). ERP II: best practices for successfully implementing an ERP upgrade. *Communications of the ACM*, 49(3), 105-109.
- Xu, L., Yu, W. F., Lim, R., & Hock, L. E. (2010, 15-17 July). *A methodology for successful implementation of ERP in smaller companies*. Paper presented at the 2010 IEEE International Conference on Service Operations and Logistics and Informatics, Qingdao, China.
- Kalema, B.M. Olugbara, O.O. & Kekwaletswe, R.M. (2014). Identifying critical success factors: the case of ERP systems in higher education. *The African Journal of Information Systems*, 6(3), 65-84.
- Abdelghaffar, H. (2012). Success factors for ERP implementation in large organizations: the case of Egypt. *The Electronic Journal of Information Systems in Developing Countries*, 52.
- Chang, S.I. (2004). *ERP life cycle implementation, management and support: implications for practice and research*. Paper presented at the 37th Annual Hawaii International Conference on System Sciences, Big Island, Hawaii.
- Grabski, S.V. Leech, S.A. & Schmidt, P.J. (2011). A review of ERP research: a future agenda for accounting information system. *Journal of information systems*, 25(1), 37-78.
- Kvavik, R.B. (2002). *The promise and performance of enterprise systems for higher education* (Vol 4). Boulder, Colo: EDUCAUSE Center for Applied Research.
- Abugabah, A. & Sanzogni, L. (2010). Enterprise resource planning (ERP) system in higher education: a literature review and implications. *International Journal of Human and Social Sciences*, 5(6), 395-399.
- Almarri, K., & Boussabaine, H. (2017). The influence of critical success factors on value for money viability analysis in public-private partnership projects. *Project Management Journal*, 48(4), 93-106.
- AlQashami, A., & Heba, M. (2015). *Critical success factors (CSFs) of enterprise resource planning (ERP) system implementation in Higher Education Institutions (HEIs): concepts and literature review*. Paper presented at the Fourth International Conference on Advanced Information Technologies and Applications (ICAITA 2015). Dubai, UAE.

- Al-Shamlan, H.M. & Al-Mudimigh, A.S. (2011). The Chang management strategies and processes for successful ERP implementation: a case study of MADAR. *International Journal of Computer Science*, 8, 431-435.
- Arthur, E. A. (2016). *Successful enterprise resource planning system implementation: a higher educational managerial perspective*. Doctoral dissertation, Walden University.
- Shaul, L. & Tauber, D. (2013). Critical success factors in enterprise resource planning systems: review of the last decade. *ACM Computing Surveys (CSUR)*, 45(4), 55.
- Rockart, J.F. (1979). Critical success factors. *Harvard Business Review*, 57(2), 81-91.
- Hedman, J. (2010). ERP systems: critical factors in theory & practice. *Center for Applied ICT (CAICT), CBS, Frederiksberg*.
- Nah, F.F.H. & Delgado, S. (2006). Critical success factors for enterprise resource planning implementation and upgrade. *Journal of Computer Information Systems*, 46(5), 99.
- Finney, S. & Corbett, M. (2007). ERP implementation: a compilation and analysis of critical success factors. *Business Process Management Journal*, 13(3), 329-347.
- Upadhyay, P., & Dan, P. K. (2008, 18-21 May 2008). *An explorative study to identify the Critical Success Factors for ERP implementation in Indian small and medium scale enterprises*. Paper presented at the International Conference on Information Technology, Gdansk, Poland.
- Dezdar, S. & Sulaiman, A. (2009). Successful enterprise resource planning implementation: taxonomy of critical factors. *Industrial Management & Data Systems*, 109(8), 1037-1052.
- Allen, D. & Kern, T. (2001). Enterprise resource planning implementation: stories of power, politics, and resistance. *Realigning Research and Practice in Information Systems Development*, (pp. 149-162): Springer.
- Esteves, J., & Pastor, J. (2000, 1-2 November 2000). *Towards the unification of critical success factors for ERP implementations*. Paper presented at the 10th Annual BIT Conference, Manchester, UK.
- Shanks, G. (2000). A model of ERP project implementation. *Journal of Information Technology*, 15(4), 289-303.
- Zhang, L., Lee, M. K., Zhang, Z., & Banerjee, P. (2003, 6 - 9 January 2003). *Critical success factors of enterprise resource planning systems implementation success in China*. Paper presented at the 36th Annual Hawaii International Conference on System Sciences, Big Island, Hawaii.
- Somers, T.M. & Nelson, K.G. (2004). A taxonomy of players and activities across the ERP project life cycle. *Information & Management*, 41(3), 257-278.
- Ram, J., Corkindale, D. & Wu, M.L. (2013). Implementation critical success factors (CSFs) for ERP: do they contribute to implementation success and post-implementation performance? *International Journal of Production Economics*, 144(1), 157-174.

- Parhizkar, M. & Comuzzi, M. (2017). Impact analysis of ERP post-implementation modifications: design, tool support and evaluation. *Computers in Industry*, 84, 25-38.
- Al-Hadi, M. A., & Al-Shaibany, N. A. (2017). Critical success factors (CSFs) of ERP in higher education institutions. *International Journal*, 7(4), 92-95.
- Frimpon, M.F. (2012). A re-structuring of the enterprise resource planning implementation process, *International Journal of Business and Social Science*, 3(1), 231-243.
- Odunaike, S., Olugbara, O., & Ojo, S. (2013, March 13 - 15, 2013). *E-learning implementation critical success factors*. Paper presented at the International MultiConference of Engineers and Computer Scientists 2013 (IMECS 2013), Hong Kong.
- Linss, V. & Fried, A. (2009). Advanced impact analysis: the ADVIAN® method - an enhanced approach for the analysis of impact strengths with the consideration of indirect relations. *Papers and preprints of the Department of Innovation Research and Sustainable Resource Management*, 1.
- Linss, V. & Fried, A. (2010). The ADVIAN® classification— a new classification approach for the rating of impact factors. *Technological Forecasting and Social Change*, 77(1), 110-119.
- Soja, P. (2006). Success factors in ERP systems implementations: lessons from practice. *Journal of Enterprise Information Management*, 19(4), 418-433.
- Ganesh, L. & Mehta, A. (2010). Critical success factors for successful enterprise resource planning implementation at Indian SMEs. *International Journal of Business, Management and Social Sciences*, 1(1), 65-78.
- Kuusi, O. (1999). Expertise in the future use of generic technologies (Vol. 59). Government Institute for Economic Research (VATT), Helsinki.
- Worrell, J.L., Di Gangi, P.M. & Bush, A.A. (2013). Exploring the use of the Delphi method in accounting information systems research. *International Journal of Accounting Information Systems*, 14(3), 193-208.
- Heuer, R.J. & Pherson, R.H. (2010). *Structured analytic techniques for intelligence analysis*, CQ Press, Washington DC.
- Mphahlele, M., Olugbara, O., Ojo, S. & Kouriey, D. (2011). Cross-impact analysis experimentation using two techniques to revise marginal probabilities of interdependent events. *ORiON*, 27(1), 1-15.
- Schlange, L.E. & Jüttner, U. (1997). Helping managers to identify the key strategic issues. *Long Range Planning*, 30(5), 777-786.
- De Jouvenel, H. (2000). A brief methodological guide to scenario building, *Technological Forecasting and Social Change*. 65(1), 37-48.

- Vester, F. (1987). Der Papiercomputer. *Management Wissen*, 10, 48-57.
- Duperrin, J. & Godet, M. (1973). The method for hierarchical system elements. *Rapp. Econ. De CEA*.
- Asan, U., Bozdağ, C.E. & Polat, S. (2004). A fuzzy approach to qualitative cross impact analysis. *Omega*, 32(6), 443-458.
- Guertler, B. & Spinler, S. (2015). Supply risk interrelationships and the derivation of key supply risk indicators. *Technological Forecasting and Social Change*, 92, 224-236.
- Cole, A., Allen, W., Kilvington, M., Fenemor, A. & Bowden, B. (2007). Participatory modelling with an influence matrix and the calculation of whole-of-system sustainability values. *International Journal of Sustainable Development*, 10(4), 382-401.
- Light, B. (2001). The maintenance implications of the customization of ERP software. *Journal of software maintenance and evolution: research and practice*, 13(6), 415-429.